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Science and Technology
GUIDE
Published by the University of Missouri - Columbia Extension Division
energy information

Energy for Missouri Farm Buildings

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Although energy used in agriculture is a small portion of the total energy used in the United States, it is rapidly becoming a major cost for farmers. For example, Missouri hog farmers now spend nearly $1 for heat energy per pig weaned.

Engineers use Btu as a measure of energy needs. A Btu is a British thermal unit, a unit of energy technically defined as the amount of heat needed to raise one pound of water one degree Fahrenheit. In more practical terms, a Btu is about equal to the amount of energy we get from burning an old fashioned wooden match.

Table 1 shows some typical energy needs for farm buildings.

Fossil fuels or electricity supply virtually all the energy used on farms today. Although energy is sold in a variety of units, such as gallons, cubic feet, cords, and kilowatt hours, the wise shopper knows that energy needs are for Btu and that selling units do not reflect energy content. Table 2 lists commonly used fuels, selling units, and energy content.

To convert fuel into usable heat energy, we need some type of burner or conversion system. With the exception of electrical resistance heaters, none of these systems extract all the energy out of their fuel sources. Some heat is always lost up the chimney or through the heat distribution system in the building. Table 2 also includes average system efficiencies and the net available energy for each type of fuel.

Comparing fuel costs on a cost per available Btu basis is desirable. A common question is "Which is less expensive, LP gas or electricity?" Figure 1 will enable you to make this comparison for yourself.

Example: Suppose you are able to purchase natural gas at 43¢ per 100 cubic feet (therm). What would other fuels cost on an equal available Btu basis? Drawing a horizontal line across Figure 1 at the 43¢ mark for natural gas, you will find the following equivalents:

LP gas	40¢ per gallon
fuel oil	53¢ per gallon
electricity	1.9¢ per kWh
coal	$88 per ton
wood	$98 per cord

Table 1. Daily energy needs for farm buildings on an average January day in Missouri.

USE	BTU
Hot water floor heat in farrowing house	14,000/crate
Warm ventilating air in swine nursery	3,600
Warm ventilating air in farrowing house	14,000/sow and litter
Operate one 250-watt heat lamp	20,500
Heat 1 gallon of hot water	800
Heat farm shop	600-1,000/sq ft of floor space
Heat well insulated farm home	400/sq ft. of floor space

Table 2. Energy content and system efficiencies for common fuels.

FUEL	SELLING UNIT	HEAT CONTENT (BTU/SELLING UNIT)	AVERAGE SYSTEM EFFICIENCY (%)	AVAILABLE HEAT PER SELLING UNIT (BTU)
Natural Gas	100 cu. ft.	100,000	80	80,000
LP gas	gallon	92,000	80	73,600
#2 oil	gallon	140,000	70	98,000
electricity	kWh	3,413	100**	3,413
coal	ton	25 million	65	16.25 million
wood*	cord*	27.5 million	65	17.9 million

*Values for air dried hardwood at 20 percent moisture content. One cord = 128 cubic feet.

**Efficiency given is for individual resistance heaters (baseboard, radiant type, ceiling cable, etc.). For central furnace units using electricity, duct losses reduce efficiency about 10 percent.

The Solar Alternative

Since 1974, the public has been more interested in the use of solar energy to replace conventional heat sources. The energy itself is free, but systems required to collect, store, and distribute it are frequently more expensive than other alternatives.

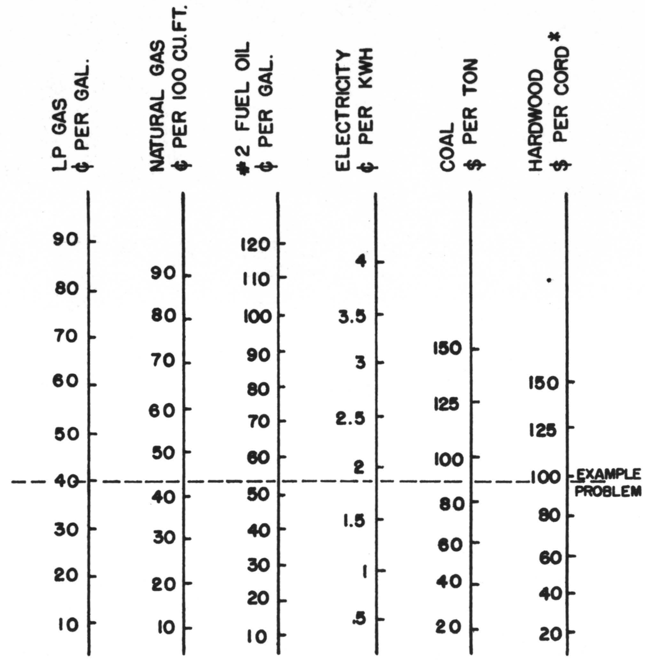
The amount of solar energy that strikes a flat, horizontal surface at 40° north latitude in Missouri averages 1,780 Btu per square foot on a clear day. This ranges from a low of 782 Btu in December to a high of 2,648 Btu in June. Using these values, we find that a flat surface slightly larger than 5 x 5 feet would receive energy equivalent to one gallon of LP gas on a clear June day.

Unfortunately, several factors prevent us from receiving or using this theoretical ideal. First, the sun does not shine every day. In Central Missouri, it averages only 62 percent of the possible hours for the year. This ranges from a low of 48 to 53 percent during the December to February heating season to a high of 75 percent in July. We still receive solar radiation on cloudy days but generally at too low a level to be used effectively in a solar collection system.

Atmospheric contamination also affects the amount of solar energy we receive. Dust, haze, fog, and moisture all decrease the energy reaching the earth from the sun.

No mechanical system is 100 percent efficient. Just as we are not able to extract all the energy from a gallon of fuel oil, we cannot capture all the sun's energy. Currently, research shows that we can capture and use 40 to 60 percent of the solar energy that strikes a particular collector with most being in the 40 percent range.

Finally, collector orientation affects the energy captured. Ideally, a collector would be oriented with its surface perpendicular or exactly at a right angle to the sun's rays from morning to night. This requires a fairly expensive tracking device and some means of continuously re-aiming the collector. A more practical solution is to fix the collector at some compromise position and accept a reduction in efficiency. The amount of expected energy for a year from



* 128 CU. FT. OF AIR DRY WOOD

Figure 1. Fuel cost equivalents for available Btu.

collectors facing South at horizontal, vertical, and optimum slopes can be found in Table 3. These data can be combined with collector efficiencies and atmospheric conditions to arrive at estimates of solar energy gathered by a particular system.

Realistic estimates of daily energy capture for solar collectors in Missouri appear to be in the following ranges:

500 Btu per square foot per day in December
900 Btu per square foot per day in June

Table 3. Maximum daily solar radiation, optimum collector tilt angle, and expected percent of total possible sunlight received at 40° north latitude in Missouri.

Date	Radiation (Btu/sq. ft./day) normal to sun	horizontal surface	vertical surface	surface at optimum tilt angle	Expected % Possible Sun received	Optimum Tilt Angle for Collector
Jan 21	2182	948	1726	1944	53	60
Feb 21	2640	1414	1730	2200	53	51
Mar 21	2916	1852	1484	2330	57	40
Apr 21	3092	2274	1022	2400	60	29
May 21	3160	2552	724	2450	62	20
Jun 21	3180	2648	610	2500	69	16.5
Jul 21	3062	2534	702	2450	75	20
Aug 21	2916	2244	978	2400	71	29
Sep 21	2708	1788	1416	2228	69	40
Oct 21	2454	1348	1654	2098	66	51
Nov 21	2128	942	1686	1908	57	60
Dec 21	1978	782	1646	1800	48	63.5
Average	2700	1780	1280	2225	62	40

Optimum Tilt Winter Months: 54°
Optimum Tilt Summer Months: 25°

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914 in cooperation with the United States Department of Agriculture. Leonard C. Douglas, Acting Director, Cooperative Extension Service, University of Missouri and Lincoln University, Columbia, Missouri 65211. ■ An equal opportunity institution.

 New 3/80/15M